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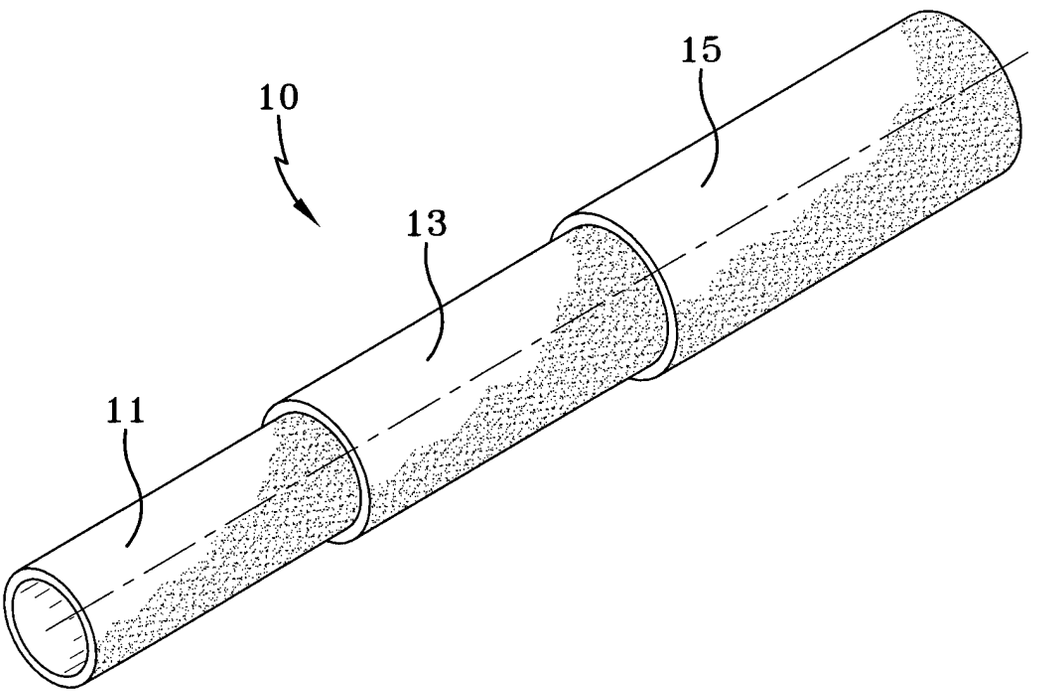
## (54) Hose construction containing polymer composition

(57) The present invention relates to a hose (10) having at least one rubber layer (11, 15) comprising from 60 to 95 parts by weight of ethylene vinyl acetate (EVM) and from 5 to 40 parts by weight of a polyacrylic rubber (ACM).




FIG–1

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## Description

### Background of the Invention

**[0001]** Elastomeric compounds useful in the fabrication of automotive hoses include chlorinated polyethylene, chlorosulfonated polyethylene and epichlorohydrin elastomers as disclosed for example in US-A- 5,683,773. Compounds made using these polymers possess good mechanical properties, low compression set, good low temperature flexibility, and good dynamic fatigue resistance. These compounds also exhibit excellent aging, weathering, chemical and ozone resistance due to their saturated backbones, and the polarity contributed by the chlorine and ether components provide good oil swell resistance.

**[0002]** Newer specifications for automotive hose compounds require air and oil resistance at temperatures of up to 175°C. Compounds comprising chlorinated polyethylene and chlorosulfonated polyethylene compounds cannot be used at these higher temperatures. Copolymers and terpolymers of ethylene and alkyl acrylates are useful as hose compounds at higher temperatures, but are expensive to use.

**[0003]** US-A- 4,759,388 discloses a hose comprising inner and outer tubes of an acrylic rubber. The acrylic rubber may be acrylic acid lower alkyl ester alone, or the ester as a main component polymerized with copolymerizable monomer under the presence of a crosslinking agent. The acrylic rubber may be a copolymer comprising acrylic acid lower alkyl ester as a main component and ethylene and vinyl acetate as copolymer components. The crosslinking agent may be an acrylic acid derivative having one of carboxyl group, epoxy group and chlorine atoms, or a methacrylic acid derivative.

**[0004]** EP-A- 0 370 361 discloses soft, elastic polymer mixtures based on crosslinked, particulate alkyl acrylate rubbers and hydrolyzed ethylene vinyl acetate copolymers.

**[0005]** US-A- 5,274,035 discloses ethylene vinyl acetate compositions and medical tubing made therefrom. The compositions comprise a major amount of ethylene vinyl acetate and a minor amount of one or more other polymers. The other polymers may include a terpolymer of an alpha olefin, an acrylic ester, and an olefinically unsaturated dicarboxylic acid, such as ethylene/methyl acrylate/maleic anhydride. Suitable ethylene vinyl acetate comprises from 5 to 50 percent by weight of vinyl acetate.

**[0006]** US-A- 5,492,971 discloses a curable ethylene copolymer blend composition which is a blend of an ethylene dipolymer, an ionomer of an ethylene unsaturated acid copolymer, and a peroxide curing agent. The ethylene dipolymer may be ethylene vinyl acetate. The ionomer may be ethylene/methyl acrylate/ethyl hydrogen maleate.

**[0007]** Paper No. 187 presented at the meeting of the Rubber Division, American Chemical Society, Orlando, Florida, September 21 through 24, 1999, discloses the use of ethylene vinyl acetate in compounds suitable for use in automotive hoses. The ethylene vinyl acetate compounds disclosed utilize enhanced viscosity ethylene vinyl acetate that has been partially crosslinked via peroxide or radiation. The ethylene vinyl acetate compounds therein are shown to have superior high temperature property retention as compared with compounds of chlorosulfonated polyethylene or ethylene/methyl acrylate terpolymer.

### Summary of the Invention

**[0008]** The present invention relates to hose, more particular to an automotive hose, having at least one rubber layer comprising from 60 to 95 parts by weight of EVM, and from 5 to 40 parts by weight of ACM.

### Brief Description of the Drawings

**[0009]**

Figure 1 is a perspective view of a hose according to the invention.

### Detailed Description of the Invention

**[0010]** When a hose, for example, as shown in Figure 1 is produced, one or more components may be formed from a polymer composition comprising a copolymer of ethylene and vinyl acetate (ethylene vinyl acetate or EVM), and a crosslinkable polyacrylic rubber (ACM).

**[0011]** Ethylene vinyl acetate preferably suitable for use in the composition may be produced by methods as are known in the art, for example, as taught in US-A- 5,093,450, 5,089,579 or 5,135,988. Suitable EVM preferably contains from 40 to 80 percent by weight of vinyl acetate. In one embodiment, the EVM contains from 50 to 70 percent by weight of vinyl acetate. Suitable EVM is available from various commercial sources, including DuPont, Millennium Petrochemicals, Nova-Borealis Compounds LLC, AT Plastics Inc., Exxon, ATO Chem, Bayer AG, and others. In one embodiment,

the EVM is of the Levapren series from Bayer. The EVM may be present in the composition in an amount ranging from 60 to 95 parts by weight. Alternatively, the EVM may be present in a range from 70 to 90 parts by weight, alternatively, from 80 to 90 parts by weight.

**[0012]** Crosslinkable polyacrylic rubber suitable for use in the composition may be produced by methods as are known in the art, for example, as taught in US-A- 5,250,644. Crosslinkable polyacrylic rubber is also known in the art as ACM, acrylic based elastomer, alkylacrylate copolymer, poly(alkyl acrylate), poly[(1-alkoxy carbonyl)ethylene], or polyacrylate rubber. Suitable ACM may be produced by free radical polymerization of any of the acrylic acid esters which have been usually used in the preparation of acrylic rubbers. Representative examples of the acrylic acid esters are, for instance, an alkyl acrylate such as methyl acrylate, ethyl acrylate, butyl acrylate or 2-ethylhexyl acrylate, an alkoxyalkyl acrylate such as methoxyethyl acrylate, and the like. Alkyl acrylates having a $C_1$ to $C_8$ alkyl group and alkoxyalkyl acrylates having a $C_2$ to $C_8$ alkoxyalkyl group wherein the alkoxy group has 1 to 4 carbon atoms are generally used. These acrylic acid esters may be used alone or in admixture thereof. In one embodiment, the ACM is a copolymer of ethyl acrylate, butyl acrylate, and methoxyethyl acrylate.

**[0013]** ACM is preferably copolymerized with cure site co-monomers to impart a crosslinkability. For example, acrylic acid esters are copolymerized with halogen-containing cure site monomers such as 2-chloroethyl vinyl ether and vinyl chloroacetate, epoxy monomers such as allyl glycidyl ether, glycidyl acrylate and glycidyl methacrylate, or alkylacrylic acid derivatives, so that the obtained acrylic rubbers can be crosslinked with a crosslinking agent or curing agent, e. g. a fatty acid soap or an amine compound such as ethyltetramine or tetraethylpentamine. Carboxylate type cure site monomers may also be used, as well as dual cure site monomers, for example, halogen-containing monomers and carboxylate monomers in the same ACM. In one embodiment, the ACM contains vinyl chloroacetate as a cure site monomer.

**[0014]** Suitable ACM is available commercially from several sources, including Hytemp 4053EP, Nipol AR74, Nipol AR72AF, and the like. ACM may be used in the composition in a range of from 5 to 40 parts by weight. Alternatively, ACM may be used in a range of from 10 to 30 parts by weight; alternatively from 10 to 20 parts by weight.

**[0015]** EVM and ACM thus together make up 100 parts by weight of rubber as used in the composition. Additional components as may be added to the composition are referred to on a parts per hundred rubber basis (phr), based on the 100 parts of EVM and ACM.

**[0016]** In addition to EVM and ACM, the rubber composition may contain conventional additives including reinforcing agents, fillers, pigments, accelerators, antiozonants, antioxidants, processing oils, activators, initiators, plasticizers, waxes, prevulcanization inhibitors, extender oils and the like.

**[0017]** Representative reinforcing agents include carbon black, which is typically added in amounts ranging from 5 to 200 parts by weight based on 100 parts by weight of total rubber (phr). In one embodiment, carbon black is used in amounts ranging from 10 to 120 phr; in another embodiment carbon black is used in a range of from 35 to 90 phr. Typical carbon blacks that are used include N110, N330, N332, N472, N550, N630, N642, N650, N762, N770, N907, N908, N990 and N991.

**[0018]** The commonly employed siliceous pigments which may be used in the rubber composition include conventional pyrogenic and precipitated siliceous pigments (silica), although precipitated silicas are preferred. The conventional siliceous pigments preferably employed in this invention are precipitated silicas such as, for example, those obtained by the acidification of a soluble silicate, e.g., sodium silicate.

**[0019]** Such conventional silicas might be characterized, for example, by having a BET surface area, as measured using nitrogen gas, preferably in the range of 40 to 600, and more usually in a range of 50 to 300 square meters per gram. The BET method of measuring surface area is described in the Journal of the American Chemical Society, Volume 60, Page 304 (1930).

**[0020]** The conventional silica may also be typically characterized by having a dibutylphthalate (DBP) absorption value in a range of 100 to 400, and more usually 150 to 300.

**[0021]** The conventional silica might be expected to have an average ultimate particle size, for example, in the range of 0.01 to 0.05 micron as determined by the electron microscope, although the silica particles may be even smaller, or possibly larger, in size.

**[0022]** Various commercially available silicas may be used, such as, only for example herein, and without limitation, silicas commercially available from PPG Industries under the Hi-Sil trademark with designations 210, 243, 532 EP etc; silicas available from Rhodia, with, for example, designations of Z1165MP and Z165GR and silicas available from Degussa AG with, for example, designations VN2 and VN3, etc.

**[0023]** Other fillers which may be used include talc, clay, calcium carbonate, and the like. Other fillers may be used in an amount ranging from 5 to 150 phr. Oil dispersions containing such fillers may also be used.

**[0024]** Organosilanes such as 3,3' bis(triethoxysilylpropyl) tetrasulfide may be used in amounts ranging from 0.1 to 20 phr. Suitable examples of such organosilanes are disclosed in US-A- 4,128,438 incorporated herein by reference in its entirety. Representative of the antidegradants which may be in the rubber composition include microcrystalline wax, paraffinic wax, monophenols, bisphenols, thiobisphenols, polyphenols, hydroquinone derivatives, phosphites,

phosphate blends, thioesters, naphthylamines, diphenol amines, substituted and unsubstituted diaryl amine derivatives, diarylphenylenediames, para-phenylene diamines, quinolines and blended amines. Antidegradants are generally used in an amount ranging from 0.1 phr to 10 phr with a range of from 2 to 6 phr being preferred. Representative of processing oils which may be used in the rubber composition of the present invention include activated dithio-bisbenzanilide, poly-para-dinitrosobenzene, xylyl mercaptans, aliphatic-naphthenic aromatic resins, polyethylene glycol, petroleum oils, ester plasticizers, vulcanized vegetable oils, pine tar, phenolic resins, synthetic oils, petroleum resins, polymeric esters and rosins. These processing oils may be used in a conventional amount ranging from zero to 140 phr. The rubber layer may contain magnesium oxide in conventional amounts. However, it has been found that the presence of magnesium oxide in the rubber layer may be detrimental to adhesion and/or bleeding of the hose components. Therefore, in a preferred embodiment, the rubber layer does not contain magnesium oxide. These additives are conventionally used in amounts ranging from 0.1 to 25 phr.

**[0025]** The elastomeric compositions for use in the coating layer can be crosslinked by various peroxide containing curing agents. Curing agents which may be employed in the compositions of the invention include, for example, ditertbutyl peroxide, dicumyl peroxide, benzoyl peroxide, 2,4-dichlorobenzol peroxide, t-butyl-cumyl peroxide, t-butyl perbenzoate, t-butyl peroxide, t-butylperoxy (2-ethyl hexanoate), 2,5-dimethyl-2,5-di(benzoylperoxy)-hexane, benzoyl peroxide, 2,5-dimethyl-2,5-(t-butyl peroxy)-hexane, 1,1-ditert-butyl peroxy-3,3,5-trimethyl cyclohexane, 4,4-ditert-butyl peroxy n-butyl valerate and n-butyl-4,4-bis(t-butyl peroxy) valerate. Additional curing agents which may be employed include diacyl or dialkyl peroxides such as $\alpha,\alpha$'-bis(t-butylperoxy)-isopropylbenzene, 2,5-Dimethyl-2,5-di(t-butylperoxy) hexane, Di-t-butyl peroxide, 2,5-Dimethyl-2,5-di-(t-butylperoxy)hexyne-3, lauroyl peroxide, t-butyl hydroperoxide, t-amyl hydroperoxide, cumene hydroperoxide, t-butyl perbenzoate, t-butyl peroxide, t-butylperoxy (2-ethyl hexanoate), 2,5-dimethyl-2,5-di (benzoylperoxy)-hexane and benzoyl peroxide. All of the above curing agents are commercially available.

**[0026]** The amount of curing agent that can be used may vary. Generally speaking, the level will range of from 0.1 to 15 phr (based on active parts of peroxide). Preferably, the level ranges from 2 to 10 phr.

**[0027]** Crosslinking coagents may be added to the rubber composition. Representative examples of such coagents include triallyl cyanurate, triallyl isocyanurate, triallyl phosphate, triallyl trimellitate, diallylidene pentaerithryte, diallyl terephthalate, tetraallyl oxyethane, triallyl citrate, acetyl triallyl oxyethane, acetyl triallyl citrate, di-, tri-, tetra- and penta-functional acrylates, di-, tri-, tetra- and penta-functional methacrylates, n,n'-m-phenylene-dimaleimide, 1,2-cis-polybutadiene and mixtures thereof. Typical amounts of such coagents range from 1 to 20 phr. Preferred ranges of coagents include of from 2 to 10 phr.

**[0028]** The mixing of the rubber composition can be accomplished by methods known to those having skill in the rubber mixing art. For example, the ingredients may be mixed in one stage but are typically mixed in at least two stages, namely at least one non-productive stage followed by a productive mix stage. The final curatives including vulcanizing agents are typically mixed in the final stage which is conventionally called the "productive" mix stage in which the mixing typically occurs at a temperature, or ultimate temperature, lower than the mix temperature(s) than the preceding non-productive mix stage(s).

**[0029]** Curing of the rubber composition is preferably carried out at conventional temperatures ranging from 160°C to 190°C. More preferably, the curing is conducted at temperatures ranging from 170°C to 180°C.

**[0030]** The compositions may be used in the fabrication of hoses and the like such as hoses useful in automotive applications. The compositions may be extruded or otherwise fabricated as one or more layers of a single or multilayered hose. Other layers in the hose may be fabricated from materials as are known in the art.

**[0031]** Referring now to FIG. 1, a transmission oil cooler hose 10 constructed according to one embodiment of the present invention is shown. The hose 10 comprises an inner layer 11, a reinforcement layer 13 overlaying and preferably adhered to the inner layer 11, and an outer cover layer 15 overlaying and preferably adhered to the reinforcement layer 13. The reinforcement layer 13 is formed of a suitable reinforcement material which may include organic or inorganic fibers or brass-plated steel wires. The reinforcement material is preferably an organic fiber material, such as nylon, polyester, aramid, cotton or rayon. The reinforcement construction may be of any suitable type such as braid, spiral, knit or wrapped, but in the embodiment shown, is of a braid construction. The reinforcement may further be treated with a sizing such as an RFL-type treatment to promote adhesion between the reinforcement and the inner and outer layers.

**[0032]** The inner layer 11 may consist of multiple elastomeric layers which may or may not be of the same composition, however in the preferred embodiment shown, the entire inner layer is made of the composition of the present invention.

**[0033]** The elastomeric outer cover layer 15 is made of suitable materials designed to withstand the exterior environment encountered. In the preferred embodiment shown, the outer cover layer 15 is made of the rubber composition of the present invention.

**[0034]** Other embodiments may be envisioned, including hose constructions having multiple reinforcement layers and multiple elastomeric layers. One or more of the elastomeric layers may comprise the composition of the present invention.

**[0035]** The following examples are provided to illustrate the instant invention and are not intended to limit the same. All parts are parts by weight, unless listed otherwise.

EXAMPLE I

**[0036]** In this Example, rubber compositions comprising a blend of EVM and ACM were compared to rubber compositions comprising a blend of EVM and Vamac G, identified as a terpolymer of ethylene, methyl acrylate, and a cure site monomer. Compounds were made following the compositions indicated in Table 1. Physical properties were evaluated as indicated in Tables 2.

Table 1

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Materials | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| EVM (Levapren 600) | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| AEM (Vamac G) | 30 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| ACM | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30 |
| Carbon black N550 | 40 | 40 | 20 | 20 | 40 | 40 | 20 | 20 |
| Carbon black N990 | 20 | 20 | 40 | 40 | 20 | 20 | 40 | 40 |
| Hard clay | 20 | 40 | 20 | 40 | 20 | 40 | 20 | 40 |
| Silane coupling agent | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 |
| Octyldecyl Amine | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Calcium Stearate | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| LMW Polyethylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 50% polycarbodiimide | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Hydroquinoline | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| MgO (Maglite D) | 5 | 0 | 0 | 5 | 5 | 0 | 0 | 5 |
| Peroxide (Dicup 40KE) | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Triallyl cyanurate | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |

Table 2

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Properties | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Original Properties | | | | | | | | |
| Tensile strength (MPa) | 14.9 | 15.9 | 14.6 | 14.9 | 12.7 | 13.0 | 11.4 | 11.3 |
| Elongation at break (%) | 200 | 130 | 184 | 123 | 124 | 134 | 136 | 145 |
| Shore A hardness | 85 | 86 | 79 | 85 | 79 | 84 | 76 | 82 |
| Tear strength (N/mm) | 23.2 | 27.6 | 23.9 | 27.7 | 21.7 | 23.9 | 19.5 | 17.9 |
| Compression set B, 70 Hours at 150°C | | | | | | | | |
| % Set | 37 | 38 | 40 | 39 | 33 | 27 | 37 | 33 |
| Air Aged, 70 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 15.0 | 17.6 | 15.2 | 16.4 | 13.6 | 13.7 | 12.5 | 12.5 |
| Elongation at break (%) | 118 | 78 | 116 | 122 | 124 | 88 | 164 | 119 |

Table 2 (continued)

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Air Aged, 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 15.4 | 16.0 | 14.2 | 15.4 | 12.3 | 12.3 | 12.2 | 12.2 |
| Elongation at break (%) | 97 | 67 | 94 | 74 | 79 | 57 | 110 | 85 |
| Shore A hardness | 84 | 86 | 80 | 85 | 83 | 84 | 75 | 82 |
| Oil Immersed (IRM 903), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 9.4 | 10.6 | 10.2 | 8.8 | 7.7 | 7.7 | 8.0 | 7.4 |
| Elongation at break (%) | 102 | 91 | 127 | 73 | 88 | 72 | 119 | 82 |
| Shore A hardness | 57 | 62 | 52 | 58 | 57 | 56 | 50 | 57 |
| Volume swell (%) | 60 | 52 | 58 | 55 | 54 | 46 | 52 | 47 |
| Oil Immersed (TOC), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 10.8 | 12.9 | 11.4 | 11.4 | 8.6 | 9.4 | 9.4 | 8.9 |
| Elongation at break (%) | 128 | 105 | 154 | 99 | 113 | 104 | 147 | 126 |
| Shore A hardness | 66 | 71 | 58 | 71 | 63 | 67 | 59 | 64 |
| Volume swell (%) | 27 | 23 | 26 | 26 | 24 | 21 | 22 | 22 |
| Oil Immersed (TOC), 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 12.6 | 13.0 | 10.4 | 10.6 | 10.4 | 9.8 | 9.5 | 8.5 |
| Elongation at break (%) | 80 | 101 | 141 | 76 | 118 | 127 | 166 | 120 |
| Shore A hardness | 71 | 62 | 55 | 66 | 59 | 54 | 51 | 58 |
| Volume swell (%) | 30 | 30 | 33 | 30 | 27 | 25 | 27 | 26 |

**[0037]** As seen in the data of Table 2, EVM (Levapren 600HV) can be blended with AEM and ACM to produce compounds capable of handling air agings and immersions at temperatures of up to 175°C. AEM blends provide slightly higher tensile and modulus values while ACM blends were slightly better for oil resistance, retained elongation, and compression set.

EXAMPLE II

**[0038]** In this Example, rubber compositions comprising a blend of EVM and ACM were compared to rubber compositions comprising EVM with no added ACM. Compounds were made following the compositions indicated in Tables 3A and 3B. Physical properties were evaluated as indicated in Tables 4A and 4B.

Table 3A

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Materials | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| EVM, Levapren 600HV, 60% vinyl acetate | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| ACM, Nipol AR72HF, Cl cure site | 0 | 0 | 0 | 0 | 10 | 10 | 10 | 10 |
| N550 | 10 | 10 | 30 | 30 | 10 | 10 | 30 | 30 |
| N990 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Armeen 18D | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Calcium stearate | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Low MW polyethylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Polycarbodiimide | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 |

Table 3A (continued)

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Materials | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| TMQ | 0.5 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0.5 |
| Irganox 1010, CIBA | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 |
| DLTDP, Struktol | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| MgO | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 2 |
| Dicup peroxide, 265F auto-initiation | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| triallyl cyanurate | 2.5 | 0 | 2.5 | 0 | 2.5 | 0 | 2.5 | 0 |
| SR521, sartomer | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 |

Table 3B

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Materials | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| EVM, Levapren 600HV, 60% VA | 80 | 80 | 80 | 80 | 70 | 70 | 70 | 70 |
| ACM, Nipol AR72HF, Cl cure site | 20 | 20 | 20 | 20 | 30 | 30 | 30 | 30 |
| N550 | 10 | 10 | 30 | 30 | 10 | 10 | 30 | 30 |
| N990 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Armeen 18D | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Calcium stearate | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Low MW polyethylene | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Polycarbodiimide | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 0 |
| TMQ | 0 | 0.5 | 0.5 | 0 | 0 | 0.5 | 0.5 | 0 |
| Irganox 1010, CIBA | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 |
| DLTDP, Struktol | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| MgO | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 2 |
| Dicup peroxide, 265F auto-initiation | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| triallyl cyanurate | 2.5 | 0 | 2.5 | 0 | 2.5 | 0 | 2.5 | 0 |
| SR521, Sartomer | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 2 |

SR521 - Sartomer difunctional acrylate coagent (proprietary)
TMQ - trimethyl dihydroquinoline
Irganox 1010 - Tetrakis [methylene (3, 5-di-t-butyl-4-hydroxyhydrocinnamate)] methane
DLTDP - dilauryl thiodipropionate

Table 4A

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Properties | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Original Properties | | | | | | | | |
| Tensile strength (MPa) | 15.0 | 11.8 | 14.4 | 14.7 | 14.3 | 11.3 | 15.5 | 14.0 |
| Elongation at break (%) | 177 | 408 | 193 | 269 | 160 | 383 | 173 | 246 |

Table 4A (continued)

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Properties | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Original Properties | | | | | | | | |
| Shore A hardness | 62 | 60 | 74 | 71 | 64 | 58 | 73 | 71 |
| Tear strength (N/mm) | 16 | 29 | 23 | 33 | 16 | 23 | 23 | 28 |
| Compression Set B, 70 Hours at 150°C | | | | | | | | |
| % Set | 7 | 11 | 15 | 11 | 12 | 11 | 13 | 14 |
| Air Aged, 70 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 14.6 | 11.8 | 15.6 | 13.4 | 13.8 | 12.1 | 15.0 | 13.6 |
| Elongation at break (%) | 193 | 361 | 160 | 253 | 169 | 311 | 148 | 226 |
| Shore A hardness | 67 | 62 | 77 | 75 | 66 | 60 | 76 | 75 |
| Air Aged, 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 13.5 | 6.9 | 7.4 | 11.3 | 10.5 | 9.6 | 12.4 | 13.4 |
| Elongation at break (%) | 171 | 136 | 51 | 146 | 110 | 164 | 87 | 168 |
| Shore A hardness | 68 | 63 | 78 | 75 | 69 | 62 | 76 | 75 |
| Oil Immersed (IRM 903), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 7.8 | 6.5 | 9.6 | 9.0 | 8.2 | 6.4 | 9.1 | 8.4 |
| Elongation at break (%) | 115 | 259 | 130 | 187 | 116 | 238 | 119 | 166 |
| Shore A hardness | 50 | 33 | 55 | 46 | 52 | 33 | 53 | 48 |
| Volume swell (%) | 69.6 | 91.2 | 63.43 | 73.73 | 60.62 | 80.97 | 61.56 | 65.37 |
| Oil Immersed (TOC), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 9.5 | 8.6 | 12.1 | 10.7 | 9.5 | 7.9 | 11.8 | 10.2 |
| Elongation at break (%) | 155 | 373 | 186 | 245 | 152 | 324 | 178 | 224 |
| Shore A hardness | 53 | 41 | 59 | 54 | 55 | 43 | 57 | 54 |
| Volume swell (%) | 35 | 39 | 31.9 | 35.3 | 30.1 | 35 | 29.6 | 30.7 |
| Oil Immersed (TOC), 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 11.2 | 9.6 | 11.6 | 10.8 | 11.5 | 9.1 | 12.4 | 11.1 |
| Elongation at break (%) | 203 | 426 | 212 | 258 | 178 | 328 | 193 | 234 |
| Shore A hardness | 47 | 38 | 49 | 46 | 50 | 41 | 49 | 46 |
| Volume swell (%) | 38 | 45 | 39 | 40 | 34 | 41 | 33 | 35 |

Table 4B

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Properties | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Original Properties | | | | | | | | |
| Tensile strength (MPa) | 12.0 | 11.9 | 13.1 | 10.4 | 11.6 | 10.7 | 13.2 | 10.6 |
| Elongation at break (%) | 210 | 288 | 157 | 373 | 226 | 320 | 142 | 311 |
| Shore A hardness | 61 | 61 | 74 | 64 | 61 | 56 | 73 | 65 |
| Tear strength (N/mm) | 17 | 21 | 20 | 31 | 14 | 17 | 17 | 25 |

Table 4B (continued)

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Compression Set B, 70 Hours at 150°C | | | | | | | | |
| % Set | 21 | 27 | 23 | 27 | 36 | 35 | 25 | 35 |
| Air Aged, 70 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 12.9 | 11.3 | 12.8 | 11.0 | 11.5 | 10.2 | 13.6 | 11.1 |
| Elongation at break (%) | 195 | 249 | 157 | 282 | 205 | 271 | 136 | 221 |
| Shore A hardness | 62 | 60 | 76 | 69 | 64 | 59 | 76 | 72 |
| Air Aged, 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 7.3 | 10.8 | 12.2 | 7.6 | 8.3 | 8.4 | 12.6 | 11.3 |
| Elongation at break (%) | 92 | 195 | 116 | 102 | 100 | 169 | 98 | 131 |
| Shore A hardness | 66 | 63 | 75 | 72 | 66 | 60 | 74 | 72 |
| Oil Immersed (IRM 903), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 7.2 | 5.6 | 7.7 | 5.7 | 4.8 | 4.9 | 7.0 | 5.9 |
| Elongation at break (%) | 150 | 176 | 112 | 245 | 129 | 197 | 97 | 195 |
| Shore A hardness | 41 | 37 | 53 | 30 | 36 | 33 | 53 | 35 |
| Volume swell (%) | 65 | 68 | 58 | 82 | 69 | 70 | 51 | 71 |
| Oil Immersed (TOC), 168 Hours at 150°C | | | | | | | | |
| Tensile strength (MPa) | 8.4 | 6.7 | 9.6 | 7.7 | 7.7 | 6.5 | 9.0 | 7.8 |
| Elongation at break (%) | 204 | 223 | 142 | 339 | 202 | 248 | 128 | 272 |
| Shore A hardness | 47 | 44 | 56 | 39 | 42 | 38 | 57 | 44 |
| Volume swell (%) | 30 | 31 | 30 | 34 | 33 | 31 | 25 | 33 |
| Oil Immersed (TOC), 168 Hours at 175°C | | | | | | | | |
| Tensile strength (MPa) | 10.1 | 8.7 | 11.5 | 8.7 | 8.6 | 8.2 | 10.5 | 9.2 |
| Elongation at break (%) | 247 | 257 | 166 | 388 | 210 | 287 | 148 | 277 |
| Shore A hardness | 45 | 44 | 50 | 37 | 43 | 35 | 51 | 46 |
| Volume swell (%) | 35 | 35 | 33 | 40 | 34 | 34 | 27 | 35 |

**[0039]** In almost all cases tensile strength was reduced as the ACM content increased, however even at a level of 30 phr the values were sufficient for typical specifications. Modulus values also slightly decreased with increasing ACM. Compression set was heavily influenced by ACM content in that those compounds containing no ACM averaged 11 percent, while those containing 30 phr averaged 33 percent. Volume swells in both IRM903 and TOC fluid both decreased with increasing ACM content.

**[0040]** The addition of ACM to these EVM compounds provides increased resistance to volume swell and slightly lower Tg, however other properties such as tensile strength and compression set are negatively impacted. A good balance between these properties was observed when the ACM was in the 10 to 20 phr range.

## Claims

**1.** A hose **characterized by** at least one rubber layer (11, 15) comprising:

(A) from 60 to 95 parts by weight of ethylene vinyl acetate (EVM), and
(B) from 5 to 40 parts by weight of a polyacrylic rubber (ACM).

**2.** The hose of claim 1, wherein said rubber layer comprises from 70 to 90 parts by weight of EVM and from 10 to 30

parts by weight of ACM.

3. The hose of claim 1 or 2, wherein said rubber layer (11, 15) comprises from 80 to 90 parts by weight of EVM and from 10 to 20 parts by weight of ACM.

4. The hose of claim 1, wherein said EVM comprises from 40 to 80 percent vinyl acetate.

5. The hose of claim 4, wherein said EVM comprises from 50 to 70 percent vinyl acetate.

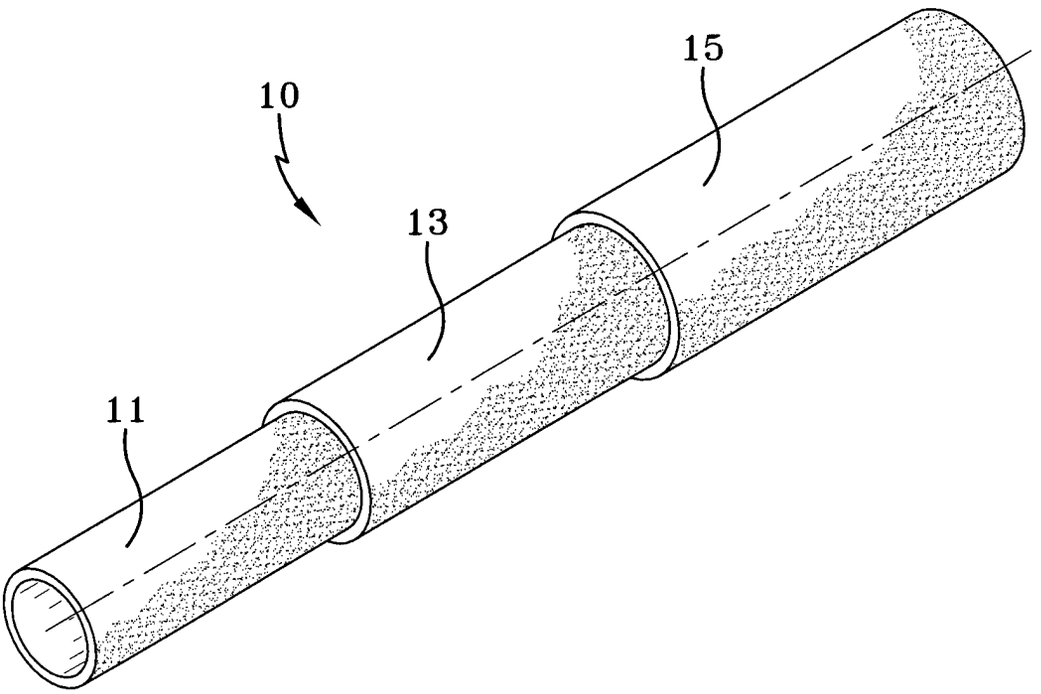
6. The hose of any of the preceding claims, wherein said ACM comprises one or more monomers selected from the group consisting of $C_1$-$C_8$ alkyl acrylates and $C_2$-$C_8$ alkoxy $C_1$-$C_8$ alkyl acrylates.

7. The hose of claim 6, wherein said ACM further comprises at least one cure site monomer.

8. The hose of claim 6 or 7, wherein said ACM further comprises at least one cure site monomer selected from the group consisting halogen-containing cure site monomers, epoxy monomers and carboxylate type cure site monomers.

9. The hose of claim 8 wherein said halogen containing monomer is vinyl chloroacetate or 2-chloroethyl vinyl ether.

10. The hose of any of the preceding claims, wherein said ACM is a copolymer comprising ethyl acrylate, butyl acrylate, methoxyethyl acrylate, and a cure site monomer.




FIG−1

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Application Number
EP 03 10 3655

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